REDUCTION OF OVERSELECTIVE RESPONDING AND ESTABLISHMENT OF A GENERALIZED RESPONSE SET ON THE BASIS OF MULTIPLE CUES UNDER MULTIPLE SCHEDULES OF POSITIVE REINFORCEMENT AND TIMEOUT

BY

MARIA DEL ROSARIO RUIZ

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1982

ACKNOWLEDGMENTS

The completion of a dissertation is a landmark in one's professional development. The road to this juncture has often seemed arduous and circuitous, and the experiences along it have been colored by thrill as well as despair. This, then, is a time to recognize and give thanks to those who have supported, and even nurtured, me along that road, and to whom I am indebted:

to my parents, models of relentless courage, who have provided an endless source of intellectual, emotional and spiritual comfort

to my teachers, Professors Brackbill, Goldstein, Johnston, Malagodi and Wolking, who have provided a constant source of intellectual stimulation and guidance, as well as personal support and encouragement

to Dr. H. S. Pennypacker, who has provided the environment in which to develop a true appreciation for discovery, and himself as a model of intellectual honesty.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	ii
LIST OF TABLES	iv
LIST OF FIGURES	v
ABSTRACT	vi
INTRODUCTION	1
METHOD	12
Subjects	12
Apparatus	13
Training Stimuli	15
Procedure	16
RESULTS	32
Responding in Multiple Schedule Components Signaled by Color, Line-Tilt and the Corresponding Color/Line-Tilt Compound	41
Responding in Stimulus Control Probes	43
Discrimination Performance Under Novel Color/Line-Tilt Compounds	44
DISCUSSION	47
APPENDIX	59
REFERENCES	77
BIOGRAPHICAL SKETCH	81

LIST OF TABLES

Table		Page
1.	The Order of Experimental Phases and the Number of Sessions in Each for Sandy	18
2.	The Order of Experimental Phases and the Number of Sessions in Each for Dawn	20
3.	Sandy's Mean Response Rate Per Session	59
4.	Dawn's Mean Response Rate Per Session	68

LIST OF FIGURES

Figure — Page

1. Sandy's median rates of responding in the first and second discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis 34

2. Sandy's median rates of responding in the third and fourth discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis 36

3. Sandy's median rates of responding in discriminations five through eight, plotted in their order of occurrence as numbered along the x-axis 38

4. Dawn's median rates of responding in the first, second and third discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis 40

Abstract of Dissertation Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

REDUCTION OF OVERSELECTIVE RESPONDING AND ESTABLISHMENT OF A GENERALIZED RESPONSE SET ON THE BASIS OF MULTIPLE CUES UNDER MULTIPLE SCHEDULES OF POSITIVE REINFORCEMENT AND TIMEOUT

By

Maria del Rosario Ruiz

December, 1982

Chairperson: H. S. Pennypacker, Jr.
Major Department: Psychology

Following acquisition of a discrimination involving a compound discriminative stimulus, developmentally delayed children often respond to only one, or to a reduced number, of the elements making up the compound when they are presented separately in stimulus control tests. In the present study, a discrimination training procedure involving multiple schedules was used to decrease the "overselective" responding of two developmentally delayed subjects. Multiple schedule contingencies were arranged for responding in the presence of single vs. multiple cues on either of two levers. Responses on one lever in the presence of a single colored circle and a single line were reinforced on a VI 1 min.:token schedule; responses on the alternate lever were on extinction. Following this training, a compound stimulus composed of the line superimposed on the colored circle was introduced. Under this three-component multiple schedule, the contingencies on the levers

remained as before in single element components, and were reversed in the compound stimulus components. With the extinction schedules, the subjects continued to respond on the reinforcement lever associated with single elements, and did not switch-over in the compound components. The extinction schedules were then replaced by two-minute timeout periods. The timeout schedule produced reliable switch-overs for both subjects. This discriminated multiple schedule performance was obtained under the punishment schedule, but not under extinction.

Stimulus control probes involving novel color/line-tilt combinations were presented following acquisition, but the subjects' performances were specific to the stimuli associated with the training schedules. However, when a series of discriminations involving additional variations of the color/line-tilt dimensions were presented under the training schedules, the number of timeouts presented following "incorrect" responses decreased for both subjects across successive discriminations.

The differential effects of extinction and timeout in decreasing errors and arranging for generalization were significant. These findings suggested that discrimination training techniques which minimize the opportunity for the occurrence of non-reinforced stimulus-response relations may be advisable in teaching developmentally delayed subjects to respond on the basis of multiple cues.

INTRODUCTION

Over the last decade a series of studies has been published describing certain learning deficits which characterize the performance of autistic and other developmentally delayed children in discrimination training tasks. Lovaas and his colleagues, the principal contributors to this thematically integrated research effort, have employed the term "stimulus overselectivity" (Lovaas, Schreibman, Koegel, & Rehm, 1971) to describe what generally occurs when such children are presented with a stimulus composed of multiple cues in discrimination tasks. The basic training and testing procedure followed across the various studies is quite similar to that originally described by Reynolds (1961) in his early studies of selective attention in the pigeon. Following acquisition of a discrimination involving a compound stimulus, these subjects typically respond to only one, or to a reduced number, of the elements making up the compound when they are presented separately in stimulus control tests.

Although stimulus overselectivity has been studied most frequently with autistic children (Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Reynolds, Newsom, & Lovaas, 1974; Rincover & Koegel, 1975; Schover & Newsom, 1976; Schreibman, 1975; Schreibman, Koegel, & Craig, 1977; Schreibman & Lovaas, 1971), several reports have pointed out that mentally retarded (Hale & Morgan, 1973; Lovaas et al., 1971; Olson, 1971; Wilhelm & Lovaas, 1976) and children

labeled learning disabled (Bailey, 1981) also display this response pattern when performing complex discriminations. Moreover, the degree of overselectivity exhibited by non-autistic retarded subjects appears to be negatively correlated with IQ level (Wilhelm & Lovaas, 1976). In addition, normal subjects have been studied, and similar findings reported on the relation between chronological (Schover & Newsom, 1976) and mental age of both normal and retarded children and overselective responding (Fischer & Zeaman, 1973; Hale & Morgan, 1973).

In the first study of this series (Lovaas et al., 1971), three groups of children--autistic, retarded and normal--received reinforcement for responding when presented with a cross-modal compound stimulus involving simultaneous auditory, visual and tactile cues. Following acquisition, the elements of the compound were presented separately to assess the degree of stimulus control acquired by each. They found that the autistic children responded primarily to one of the elements; the normal subjects responded uniformly to all three elements while the retarded group responded at intermediate levels. When nonfunctional elements were presented in isolation, overselective subjects acquired the discriminations quickly, ruling out the possibility that sensory impairments produced the original results.

Subsequent to this study, a number of systematic replications have reported similar results when the discriminative stimulus has involved the simultaneous presentation of two cross-modal (i.e., visual and auditory) cues (Lovaas & Schreibman, 1971); or when two cues either in the same visual (Koegel & Wilhelm, 1973; Schreibmen et al., 1977) or auditory (Reynolds et al., 1974) modality have been presented.

Overselective responding has been discussed as a potential contributor to the language deficits characteristic of many retarded and most autistic individuals, such as the contextually impoverished verbalizations of echolalic children (Koegel, Rincover, & Egel, 1982; Lovaas, Koegel, & Schreibman, 1979; Reynolds et al., 1974). For example, language training which requires imitation and thus the acquisition of various discriminations based on simultaneously presented visual and auditory cues is frequently ineffective (Lovaas et al., 1971). Similarly, other procedures which are highly productive in the regular classroom may in fact interfere with the learning process when used with children who have difficulties acquiring complex discriminations. Some common teaching techniques which have been ineffective with this population include observational learning procedures (Varni, Lovaas, Koegel, & Everett, 1979) and traditional prompting and fading techniques (Koegel & Rincover, 1976; Schreibmen, 1975). In such cases, control of behavior by contiguous or near-contiguous cues and transfer of stimulus control (i.e., as in prompting procedures) actually interfere with the acquisition of contextual "meaning," appearing to promote overselective responding. Along the same lines it has been shown that the behavioral gains acquired by these subjects in one learning situation (such as in a particular setting, or with a given stimulus display, or through the mediation of a specific adult), do not readily transfer or generalize to a new one (Rincover & Koegel, 1975; Schreibman & Lovaas, 1973). In many cases, "incidental" stimuli such as a particular piece of furniture or clothing, or a gesture by the adult acquire stimulus control over the target response.

The implications of these findings bear directly upon traditional formulations of maximal learning environments for these youngsters derived from research with normal subjects. More recently, research efforts have been directed at the development of a more suitable technology which adequately accommodates the behavioral characteristics of these children. One technique developed by Schreibman (1975) employs within-stimulus prompts to insure that the designated element of a compound stimulus acquires control over responding. In this procedure, the relevant element of a visual or auditory display was initially exaggerated and gradually faded to match the dimensions of the redundant elements. While this procedure was highly effective in producing the target discriminations, its main drawback is that it sidesteps the problem encountered when a subject is required to "attend" to more than one relevant element in order to master a discrimination. In other words, the subject's responses may persist under the control of a single (relevant) element and still produce reinforcement.

A second technique which has also proven effective is overtraining an already acquired discrimination (Schover & Newsom, 1976). Although this approach represents a somewhat more direct attack on the problem, the results have been equivocal. Overtraining trials alone may not be sufficient, but may require prolonged testing trials interspersed with the reinforced trials to effect the desired results (Schreibman et al., 1977).

The final technique reported represents the most straightforward attempt to reduce overselective responding (Koegel & Schreibman, 1977). In this procedure, described by the authors as "conditional discrimination training," four autistic subjects initially obtained

reinforcement for pressing a bar when either a visual or auditory stimulus was presented. After single-cue training, responding was reinforced only when the two cues were presented simultaneously; responding was not reinforced under single cues. All subjects eventually stopped responding under single cues and learned to respond to both elements. The authors reported the discriminations were learned only after many trials, in contrast to normal subjects who required only a few trials to master them. In the same study, one autistic child was taught a series of nine conditional discriminations involving discriminative stimuli with two relevant redundant cues (e.g., green square). In the test sessions, the subject was presented with three color-form combinations, one containing the original color, another containing the original form and the original compound discriminative stimulus. After two conditional discriminations, the subject made no further errors and appeared to have learned to respond to new discriminations on the basis of multiple cues.

The study by Koegel and Schreibman (1977) is perhaps the most significant reported to date in the literature on overselective responding. Its importance lies in the fact that it illustrates the first attempt in this series to exert direct control over stimulus-response relations by arranging appropriate consequences (Skinner, 1938) for their occurrence. Various authors have pointed out that differential reinforcement in the presence of a compound stimulus is not sufficient to establish predictable control over responding by any or all elements composing the stimulus (Ray & Sidman, 1970; Terrace, 1966). The animal literature, for example, contains many illustrations of "stimulus overselectivity" in various species when responses were

reinforced in the presence of compound stimuli (e.g., Lashley, 1942; LoLordo & Furrow, 1976; Ray, 1967; Reynolds, 1961; Segal & Harrison, 1978; Warren, 1953). In this sense, the occurrence of overselective responding, per se, may not be altogether surprising, but its generality among the present population is noteworthy and deserving of research efforts to elucidate the environmental manipulations which influence its development and modulation.

One variable which has been shown to determine which element of a compound stimulus will exert stimulus control over responding is prior reinforcement history. If a discrimination is established between two stimuli from the same dimension, and a second set of stimuli is subsequently added under the same reinforcement contingencies, typically, the initial stimuli alone control discrimination performance following discrimination training under the compound (Fields, 1978; Johnson & Cumming, 1968; Mackintosh, 1965). This effect has been reported when the second element was introduced abruptly (Fields, Bruno, & Keller, 1976) and gradually (Fields, 1978).

Analysis of reinforcement histories prior to the stimulus compounding operations is critical to the analysis of overselective responding, particularly when one considers that assessing element control following exposure to the compound stimulus may not always reveal the actual stimulus-response relations established in training. For example, different stimulus control tests may yield conflicting information about the actual relations acquired in training (Reynolds, 1961; Wilkie & Mason, 1976). More importantly, the influence of reinforcement history extends to the test situation itself, such that,

the reinforcement contingencies which prevail during the test may influence the acquisition process (Fields, 1979, 1981; Huguenin & Touchette, 1980).

The importance of establishing stimulus control baselines prior to the compounding operations was illustrated by Ray (1969) in a study using monkeys as subjects. Two elements with conflicting prior histories and which controlled incompatible responses were combined to form a compound stimulus. For all subjects, the unchanged element which was compatible with the compound training contingencies supported acquisition. However, even though errors dropped to zero level in the course of compound training, the reversed element continued to control the stimulus-response relations established during single element training when the reversed elements were presented alone. Thus the subjects showed no evidence of learning about the reversed reinforcement contingencies, a finding that would have gone undetected in the absence of single element baselines.

Huguenin and Touchette (1980) replicated Ray's (1969) procedure with severely retarded subjects and found that in conflict compound training under differential reinforcement, unchanged elements tended to exert control over responding, but in many cases, subjects showed evidence of learning about the reversed element contingencies. On the other hand, when nondifferential reinforcement was employed in the test trials, there was a greater tendency for the unchanged element alone to exert control. In fact, the unchanged element continued to be the only reliable source of stimulus control even with overtraining when nondifferential reinforcement tests were used. A rather significant aspect of their findings was that when elements with compatible

reinforcement histories were combined, performance in the single element baseline checks showed that both elements controlled responding. Therefore, when prior reinforcement histories were compatible, overselective responding did not occur in the presence of compound stimuli.

The significance of arranging appropriate reinforcement histories in the modulation of overselective responding was demonstrated by Koorland and Wolking (1982) in a study with learning disabled children who displayed either auditory or visual modality preferences. In bisensory learning tasks, visual and auditory versions of the same material were simultaneously presented and the subjects were asked to recall the content. One subject consistently reported the auditory version, while the second reported the visual. During training, responses based on the content presented in the non-preferred modality were differentially reinforced, producing a preference shift compatible with the reinforcement contingencies prevailing during training. The study illustrated the direct effect of reinforcement history in modulating what is frequently interpreted as an immutable attentional-behavioral deficit.

While the above is a clear illustration that unidirectional shifts in stimulus control can be reliably generated given appropriate reinforcement contingencies, bidirectional shifts in stimulus-response relations have also been obtained when reinforcement histories were directly controlled. Singh and Beale (1978) employed a variation of Wyckoff's (1952) observing response procedure with retarded subjects to measure the development of stimulus-response relations under conditions in which the relevant dimension (i.e., the dimension associated with reinforcement) of a two-dimensional stimulus was manipulated. The subjects responded on either of two observing response keys to begin a

trial--responding on one key produced color elements on the choice-response keys, while responding on the alternate key produced letter elements on the choice-response keys. The subjects were then presented with four transfer problems in alternating order in which the previously relevant dimension continued to be correlated with reinforcement contingencies (i.e., intradimensional shift) or the previously irrelevant dimension was correlated with reinforcement contingencies (i.e., extradimensional shift). With the first extradimensional shift, the subjects' rates of responding on the observing response key associated with the irrelevant dimension increased, as did their error scores on the choice-response keys. Following mastery, however, the rate of observing responses on both keys increased within trials across conditions, and acquisition in the second discrimination involving an extradimensional shift was significantly faster. These data indicated that the subjects' responses came under the control of the prevailing contingencies of reinforcement which required repeated acquisition of novel stimulus-response relations.

The foregoing analyses of overselective responding do not support the view that restricted attention is an unmodifiable (Zeaman, 1973), or potentially diagnostic (Lovaas et al., 1971; Wilhelm & Lovaas, 1976) characteristic of developmentally delayed individuals. They do, on the other hand, underscore first, the importance of employing measurement operations which literally make visible the interplay between several controlling relations, and secondly they demonstrate the role of prior history of reinforcement as a determinant of the conditions under which these relations occur.

The present study was concerned with the development of compound stimulus control over responding by developmentally delayed subjects. The strategy elected was to make reinforcement contingent upon the occurrence of specific stimulus-response relations. Ray and Sidman (1970) have pointed out that by delivering reinforcement only in the presence of certain stimuli, the likelihood of reinforcing the desired controlling relation is increased. Thus, these authors suggest that the stimulus-response relation can function as an operant unit in the establishment and maintenance of stimulus control. The approach taken in the present study follows this general scheme, and makes use of a combination of procedures each of which has been shown to facilitate the development and maintenance of stimulus control.

Early studies of stimulus control demonstrated the utility of multiple schedules in examining discrimination problems in normal and retarded children, and the sensitivity provided by rate of responding as a measure of learning (e.g., Bijou, 1961; Bijou & Orlando, 1961). In the current study, multiple schedules were used in a two-response procedure to establish independent stimulus-response relations in the presence of single color and line-tilt elements, and in the corresponding compound stimulus composed of the combination of these single elements. Three questions were of interest: first, whether discriminative responding would develop in the presence of the compound vs. single elements under the multiple schedule arrangement; and second, what schedule contingencies would most efficiently reduce errors and thus increase the cost-effectiveness of the procedure. In the second part of the study novel color/line-tilt combinations were introduced as

tests of stimulus control and to examine the course of acquisition of subsequent stimulus-response relations bowed on multiple and single stimulus cues.

METHOD

Subjects

The two subjects who participated were residents of Threshold, Inc., a day school and residential facility for autistic and other severely developmentally delayed children. Dawn was 16 years 8 months of age, and had been institutionalized for 4.5 years. Her scores on the Stanford-Binet showed her to be functioning at a mental age of 3 years 8 months, and the Leiter International Performance Scales indicated a 45 IQ. Dawn had good receptive verbal skills, but her expressive speech was characteristically echolalic. She exhibited a great deal of self-stimulatory behavior (rocking; hand flapping), and was classified in the Moderate range of retardation.

Sandy was also 16 years 8 months of age, and had been institutionalized since the age of two. Her scores on the Leiter International Performance Scales indicated a mental age of 4 years 3 months, with a 28 IQ. She frequently engaged in self-stimulatory behaviors such as flicking objects. Sandy had no vocal speech and was classified at the Profoundly-Severe level of retardation. However, during the last three years she had acquired a growing sign-language repertoire and was mainstreamed into a Special Education classroom while this project was being conducted.

Prior to the experiment, the subjects were screened for overselective responding (Lovaas et al., 1971) in a standard discrimination

training task using compound stimuli. Two different colored circles with vertical and horizontal lines superimposed were presented simultaneously on 3 in. by 5 in. notecards. The subjects were trained to point to one color-line combination arbitrarily designated as the discriminative stimulus. Stimulus control probes followed acquisition of the discrimination. Both subjects responded with 100% accuracy in the presence of the color component, but at chance levels to the line stimuli. The results were reproduced in a second variation of the procedure and indicated that, with these subjects, differential reinforcement in the presence of a compound stimulus was not sufficient to establish stimulus control of responding by both elements of the stimulus.

Apparatus

The experimental chamber consisted of a table 69 cm. high with a wooden cubicle 61 cm. long, 28 cm. deep, and 61 cm. high, placed on its center. A wooden platform raised 6 cm. was mounted inside the chamber and housed two levers set 25 cm. apart. The subject sat inside the chamber facing the stimulus display wall. The ceiling of the chamber extended 61 cm. beyond the table edge over the subject's head, and a curtain suspended around it was drawn closed during sessions. A 40W. lightbulb used as houselight provided the only illumination in the room, except for a flashlight in the Experimenter's work area.

The Experimenter sat behind the stimulus display wall and manually dropped plastic tokens through a metal chute mounted along the subject's left wall. Tokens fell into a metallic cup inside the chamber.

A "magic eye" was mounted under the token chute which the Experimenter frequently used to view the subject during sessions.

A double screen retractable panel was built into the stimulus display wall. The front panel was wooden and could be raised and latched into position out of view of the subject, or lowered into the chamber. The back panel, i.e., the stimulus display panel, was lined with white felt, and had a small hook attached to its center at the subject's eye level. This panel was hinged to the outside of the stimulus display wall and could be opened and latched closed from behind the cubicle. During sessions, the Experimenter suspended a stimulus on the hook attached to the display panel, latched it closed and secured the wooden panel in the raised position while the subject responded. To change the stimuli, the Experimenter lowered the wooden panel, opened the display panel, changed stimuli and repeated the previous operation.

Recording of responses and timing of stimulus presentations were carried out automatically through BRS Foringer solid state programming equipment set up on a table behind the cubicle next to the Experimenter. Each stimulus presentation lasted one minute, and the Experimenter initiated this interval by pressing a foot pedal activating the counters which automatically stopped recording after one minute. After this interval, the Experimenter manually changed the stimuli and recorded the counter readings for that period, a process that took 5 seconds to complete. To simplify the process, four counters were used along with a channel switch. Positioning the switch on channel 1 activated the recording of right and left lever responses on counters 1 and 2. Switching to channel 5 activated these recordings

on channels 3 and 4. Thus, when a single element was presented, the channel switch was set manually in position 1. When a compound stimulus was presented, the channel was switched to position 5. The stimulus presentation order was preset on daily data sheets which the Experimenter followed to change stimuli.

The interreinforcement intervals were taped on a cassette with a 5 second delay between schedule components. The Experimenter listened to the recordings through a small earphone attached to the cassette player. Changeover delays and limited hold intervals were timed manually with a stopwatch. The cassette recorder was turned on at the beginning of each session and ran either until a token exchange occurred, the session was completed, or until a timeout interval was initiated. During timeouts, the recorder was turned off and restarted after 2 minutes.

Training Stimuli

Three different types of stimuli were used: (a) A colored circle 10.8 cm. in diameter was cut out of construction paper and sealed between two sheets of clear adhesive plastic. A 1.3 cm. square of plastic was left attached to a tangent of the circle and a hole was perforated in the center of the square. The figure could thus be suspended from the hook inside the stimulus display panel. (b) A line strip 3.8 cm. long and .6 cm. in diameter was cut out of black construction paper. Two circles 10.8 cm. in diameter were cut out of clear adhesive plastic, and the black line was mounted and sealed along the diameter of the plastic circles. For each line stimulus, the square plastic hanger was positioned on a tangent of the circle such

that the line was suspended on a specific axis (e.g., horizontal, vertical, or 45-degree axis, etc.). (c) A compound stimulus was created by combining the single elements described above. For example, for Dawn, an orange circle and a vertical line were used as single elements. These elements were combined and presented simultaneously as a compound stimulus, that is, a vertical black line superimposed on an orange circle of the same dimensions as above. For Sandy, a green circle and a horizontal line were used. In successive experimental phases, six additional stimulus combinations were used.

Procedure

Phase 1--Multiple schedule components signaled by color and line-tilt. Sessions were held, on the average, three times per week. Initially, the subjects were allowed to exchange tokens delivered in the experimental chamber for small bites of food and sips of juice and soda. Following this exchange, they were trained to respond for tokens by depressing either of the two levers set on the work panel in the chamber. During the first session, the subjects were physically prompted to depress each lever. White plastic poker chips were manually dropped through the metal chute. Release of a poker chip by the Experimenter created a clicking sound lasting .5 seconds travel time before reaching the token cup. Tokens were delivered on a continuous reinforcement schedule, and the exchange ratio advanced to five tokens per exchange.

Both subjects had extensive histories with token reinforcement outside of the experimental chamber, so that once level pressing was established, the schedule contingencies were rapidly changed to FR 1 [Mult (Conc EXT VI 5 sec.: token) (Conc EXT VI 5 sec.: token)]. The

discriminative stimuli used in the multiple component schedules were an orange circle and a vertical line for Dawn, and a green circle and a horizontal line for Sandy. The color and line stimuli were presented in alternate order, each presentation lasting 1 minute. Under this schedule, depressions of the right lever in the presence of either the color or line stimulus were reinforced, on the average, every 5 seconds with a token. An extinction schedule was concurrently arranged on the left lever, and a 5 second changeover delay (COD) timed from the first response on the VI lever was in effect. Tokens were exchanged for edibles following each multiple schedule sub-component. At all times during this and subsequent phases throughout this experiment, extinction was in effect for simultaneous responding on both levers. During this phase, the subjects were instructed to use one hand only.

After the second session the subjects were prompted to respond on the right lever only, and to switch over when left lever responses were emitted in the presence of the discriminative stimuli. Both subjects stopped responding on the left lever after nine sessions.

Phase 1 conditions remained in effect for six weeks. A total of 18 sessions were held with Sandy and 20 with Dawn. During this time, the schedule contingencies were gradually changed such that by the end of the phase, tokens on the right lever were delivered on a VI 20 sec. schedule with a 5 second limited hold, and token exchanges occurred, on the average, after five multiple schedule sub-components, with two exchange periods per session. The transition exchange schedules used during this phase, the number of exchanges per session, and the average number of tokens per exchange are listed in Table 1 for Sandy and Table 2 for Dawn. Five minutes free time spent either playing with

Table 1

The Order of Experimental Phases and the Number of Sessions in Each for Sandy

Phase	Schedule	Mean Tokens/ Exch.	Mean Exch./ Sess.	Sess.	Total Calendar Days
1	FR1(Mult(Conc EXT VI5":T) (Conc EXT VI5":T)[a]	10	4	3	1– 4
	VR2(Mult(Conc EXT VI5":T) (Conc EXT VI5":T)	12	4	3	5–10
	VR5(Mult(Conc EXT VI20":T) (Conc EXT VI20":T))[b]	13	2	12	11–44
Total				18	45
2	VR10(Mult(Conc EXT VI20":T) (Conc EXT VI20":T) (Conc VI20":T EXT))	12	2	30	45–114
Total				30	70
3	VR12(Mult(Conc EXT VI20":T) (Conc EXT VI20":T) (Conc VI20":T EXT))	13	2	8	115–224
	VR7(Mult(Conc FR1:TO VI20":T) (Conc FR1:TO VI20":T) (Conc VI20":T FR1:TO))	14	2	2	225–232
	VR10(Mult(Conc VR2:TO VI20":T) (Conc VR2:TO VI20":T) (Conc VI20":T VR2:TO))[c]	14	2	10	233–263
	VR9(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))	11	1.5	7	264–277
Total				27	163
4	FR18(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))[d]	12	1	2	278–298
Total				2	19

Table 1--Continued

Phase	Schedule	Mean Tokens/ Exch.	Mean Exch./ Sess.	Sess.	Total Calendar Days
5	FR18(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))	13	1	40	297-390
Total				40	93

Note. Within phase, the transition Exchange Schedules, the Mean Number of Tokens per Exchange and the Mean Number of Exchanges per Session are listed. The Total Number of Calendar Days per phase is indicated in the last column.

[a]For all concurrent schedules, the first component = left lever; the second component = right lever.

[b]A 5 sec. COD was in effect for all concurrent schedules after this point; a 5 sec. Limited Hold was in effect in all VI schedules after this point.

[c]On days 261-263 a 3 sec. Limited Hold was in effect in all VI schedules.

[d]Probes were included in the Exchange Schedule values.

Table 2

The Order of Experimental Phases and the Number of Sessions in Each for Dawn

Phase	Schedule	Mean Tokens/ Exch.	Mean Exch./ Sess.	Sess.	Total Calendar Days
1	FR1(Mult(Conc EXT VI5":T) (Conc EXT VI5":T))[a]	9	4	3	1- 4
	VR2(Mult(Conc EXT VI5":%) (Conc EXT VI5":T))	11	3	3	5-10
	VR5(Mult(Conc EXT VI20":T) (Conc EXT VI20":T))[b]	12	2	14	11-44
Total				20	44
2	VR9(Mult(Conc EXT VI20":T) (Conc EXT VI20":T) (Conc VI20":T EXT))	12	2	38	45-140
Total				38	96
3	VR13(Mult(Conc EXT VI20":T) (Conc EXT VI20":T) (Conc VI20":T EXT))	13	2	2	141-143
	VR9(Mult(Conc FR1:TO VI20":T) (Conc FR1:TO VI20":T) (Conc VI20":T FR1:TO))	13	2	4	144-224
	VR8(Mult(Conc VR2:TO VI20":T) (Conc VR2:TO VI20":T) (Conc VI20":T VR2:TO))	15	2	10	225-246
	VR15(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))	13	1	15	247-276
Total				31	136
4	FR18(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))[c]	11	1	2	277-280
Total				2	119

Table 2--Continued

Phase	Schedule	Mean Tokens/ Exch.	Mean Exch./ Sess.	Sess.	Total Calendar Days
5	FR18(Mult(Conc VR2:TO VI1':T) (Conc VR2:TO VI1':T) (Conc VI1':T VR2:TO))[c]	16	1	56	281-400
Total				56	119

Note. Within phase, the transition Exchange Schedules, the Mean Number of Tokens per Exchange and the Mean Number of Exchanges per Session are listed. The Total Number of Calendar Days per phase is indicated in the last column.

[a]For all concurrent schedules, the first component = left lever; the second component = right lever.

[b]A 5 sec. COD was in effect for all concurrent schedules after this point; a 5 sec. Limited Hold was in effect in all VI schedules after this point.

[c]Probes were included in the Exchange Schedule values.

preferred toys or sitting in a rocking chair were included in the reinforcer selection list at this time. At the completion of each multiple schedule sub-component, the Experimenter manually released the double screen and changed the component schedule stimuli from behind the experimental chamber while the subjects viewed the wooden panel. In effect, an inter-component interval lasting 5 seconds occurred during multiple stimulus alternations. During session eight, Dawn continued to respond during the inter-component interval. To eliminate responding in the absence of a discriminative stimuli, a two minute timeout (TO) contingency was implemented in which the Experimenter stated loudly "No, fold your hands," and turned off the houselight in the chamber. Responding during the inter-component intervals was eliminated by the end of this session and did not recur after this.

Phase 2--Multiple schedule components signaled by color, line tilt, and the corresponding color/line-tilt compound. During week seven a third discriminative stimulus was introduced in which the single elements used in Phase 1 with each subject were combined to form a compound stimulus. For Dawn, the compound stimulus consisted of the vertical line superimposed on the orange circle, and for Sandy, the horizontal line superimposed on the green circle. The elements in the compound stimulus were in all respects equivalent to the single elements, except that now they also appeared in combination.

A third sub-component concurrent schedule was added to the multiple component schedule with the introduction of the compound stimulus, creating a three-ply multiple component schedule. With this new schedule, contingencies in the presence of the single color and line

stimuli remained as before, that is, responding on the right lever was reinforced with a token, on the average, every 20 seconds with a 5 second limited hold. Extinction was concurrently programmed on the left lever. In the presence of the compound stimulus, however, right and left lever contingencies were reversed. Responses on the left lever in the presence of the compound were reinforced on VI 20 sec.:token, 5 sec. L.H., while extinction was concurrently arranged on the right lever. A 5 second COD, as described above, was also in effect.

Throughout this phase, the three discriminative stimuli were presented in alternate order, each appearing an equal number of times per session. The total number of sessions in this phase was 38 for Dawn and 30 for Sandy. The schedule contingencies in effect were for Dawn, VR 9 [Mult (Conc EXT VI 20 sec.:token, 5 sec. L.H.)(Conc EXT VI 20 sec.:token, 5 sec L.H.)(Conc VI 20 sec.:token, 5 sec. L.H. EXT)], with a 5 second COD in effect within each sub-component concurrent schedule. The exchange schedule for Sandy was VR 10; all other conditions were the same as Dawn's. The number of exchanges per session and the average number of tokens per exchange for each subject are listed in Tables 1 and 2 for Sandy and Dawn respectively.

Phase 3--Establishment of the color/line-tilt compound as a discriminative stimulus. The experimental manipulations implemented during this phase were for the purpose of establishing reliable left lever responding and switch-overs from the right lever in the presence of the compound stimulus. A total of 27 sessions were held with Sandy, and 31 with Dawn. During the previous phase, Sandy had earned a total of three reinforcers for responding on the left lever in the presence of the compound, and Dawn had earned one. The subjects, therefore, had

very limited contact with the reinforcement contingencies in the presence of the compound stimulus. An attempt was made to "force" switch-overs on Day 114 with Sandy and 141 with Dawn by increasing the previous ratio of compound stimulus to single element presentations, thus increasing exposure to the extinction schedule on the right lever. Whereas in the previous phase each single element and the compound were presented an equal number of times (1:1 compound-element ratio), in the present session, for every single element presented there were six presentations of the compound stimulus (6:1 compound-element ratio). The length of the sessions was extended until one of two criteria was met: either the subject made at least one left lever response in the presence of the compound stimulus during five consecutive compound sub-components, or the subject emitted no left lever responses under these conditions. Token exchanges during this manipulation occurred on the average, after 13 components for Dawn, and 12 components for Sandy. In this session, Dawn was exposed to 12 presentations of the compound sub-component schedule, that is twice as many as in the previous phase, before meeting the no left lever response criterion. The number of compound sub-component schedule presentations for Sandy was five times the number in the previous phase. She was presented with 27 sub-component schedules associated with the compound stimulus before reaching the left lever response criterion.

Under the above conditions, left lever response rates in the presence of the compound stimulus were .18 responses per minute for Dawn, and 2.3 responses per minute for Sandy. An additional session was held for Sandy under the old stimulus presentation conditions (i.e., 1:1 compound-element ratio) and left lever response rates in the

presence of the compound stimulus increased slightly to 3.3 responses per minute. The rates of responding on the right (extinction) lever, however, did not deviate from previous levels at any time during these sessions for either subject.

A second manipulation was thus implemented in an attempt to "force" switch-overs in the presence of the compound stimulus and establish stimulus control of left lever responding while maintaining the same schedule contingencies. On the session held on Day 129 with Sandy and on Day 143 with Dawn, a can was used to cover the right lever in the presence of the compound stimulus. Two token exchanges were scheduled to occur during these sessions, and the number of compound sub-component schedules presented was increased such that 66% of the tokens in the first exchange and 100% of the tokens in the second had to be earned by responding in the presence of the compound stimulus. In meeting these criteria the total number of compound sub-component schedules presented was 20 for Dawn and 36 for Sandy. During the following session, the can was gradually faded out, first by uncovering the right lever and placing the can next to it, and eventually by removing it from the chamber altogether.

Attempts to fade out the lever cover from the experimental chamber on day 143 disrupted Dawn's performance; in the presence of the cover, responding on the left lever was maintained, but, in its absence, right lever responding returned to its previous levels. Therefore, a punishment contingency was introduced in this session for Dawn to "force" switch-overs. The punishment contingency replaced the extinction contingency in all multiple sub-component schedules. With this new schedule, responses on the right lever in the presence of either the

color or line stimulus continued to be reinforced every 20 seconds, on the average. Responses on the left lever were now followed by a 2 minute timeout period in which the Experimenter stated loudly "No, fold your hands," turned off the houselight and lowered the wooden panel covering the discriminative stimulus. Responses during TO had no effect, except for resetting the TO interval. In the presence of the compound stimulus, responses on the left lever were reinforced, on the average, every 20 seconds, while responses on the right lever were followed by a 2 minute TO interval as above.

The cover fading procedure was somewhat more effective with Sandy, and four sessions were held in the absence of the lever cover under the previous schedule contingencies. A nine week period followed in which no sessions were held. The subjects went home for Christmas vacation and were unavailable for sessions during part of this time. Upon their return, Sandy was mainstreamed into a Special Education classroom in the public school system, creating scheduling conflicts. Sessions were resumed during week 32 with Dawn and week 33 with Sandy. The schedule contingencies in effect prior to the break were maintained for Dawn over the next 12 sessions. For Sandy, the extinction contingencies were replaced by a timeout contingency on Day 226. The timeout operation was the same as described above.

Under this new schedule, it was observed that the subjects would often emit the first response after the introduction of the discriminative stimulus in the multiple sub-component schedules, and pause before continuing to respond. This was unusual in that, generally, both subjects responded throughout each sub-component schedule on the VI lever in a steady fashion with infrequent pauses. This new response

pattern suggested that perhaps the FR 1:TO contingency was functioning as a discriminative stimulus for switch-overs, and its absence after the first response as a discriminative stimulus for responding on a particular lever. Since the objective of the procedure was to establish stimulus control of responding by the multiple component stimuli for three discriminated operants, it was decided to change the TO contingency from FR 1 to VR 2. In this way, the discriminative control over subsequent responding potentially generated by the consequences of the first response was reduced. In effect, this manipulation was made in order to "force" the subject to attend to the multiple schedule stimuli before responding. The VR 2:TO contingency was implemented with Dawn on Day 225 and with Sandy on Day 233. On this schedule, responding on the timeout lever produced a timeout period, on the average, after two responses. All other conditions remained as before.

The ratio of single element presentations to compound stimulus presentations was changed on Day 247 to a 2:1 compound-element ratio; that is, for each presentation of the color or line stimulus, there were two presentations of the compound stimulus. This change was made in order to insure equivalent reinforcement rates on both levers each session. The multiple sub-component schedules after this point were alternated in irregular order.

Sandy's rates of responding declined to below 50% of the previous level during weeks 35 to 38. On Days 261-263, the 5 second limited hold on the VI schedules was reduced to 3 seconds in an attempt to increase her rates of responding. This manipulation had no effect, and a second manipulation was thus undertaken. Prior to the session on Day 264, Sandy was exposed to a mini re-training session in which

tokens were delivered on the original VI 5 sec schedule. The mini session lasted four minutes, and four multiple sub-component schedules were presented, with two token exchanges. Response rates following the mini session recovered to previous levels.

During Phase 3, the token reinforcement schedules were gradually leaned to VI 1 min. By the end of the phase, token exchanges occurred, on the average, after 15 components for Dawn and 9 for Sandy. The transition exchange schedules used during this phase, the number of exchanges per session, and the average number of tokens per exchange for each subject are listed in Table 1 for Sandy and Table 2 for Dawn.

Phase 4--Stimulus control probes. Both subjects had performed without errors over the last 13 sessions in Phase 3; that is, in the presence of single elements, all responses were made on the right lever. Conversely, in the presence of the compound stimulus, all responses were made on the left lever. The elements making up the compound stimulus were in all respects equivalent to the single elements, except that in the compound, they were combined and appeared simultaneously. The subjects' performance indicated that, under the present conditions, both dimensions of the compound were functional; in other words, both exerted stimulus control over left lever responding.

Stimulus control probes were held for each subject over two consecutive sessions, using a new set of stimuli. Dawn was presented with Sandy's training stimuli--a green circle, a horizontal line and the compound of these, a horizontal line superimposed on a green circle. Similarly, Sandy was presented with Dawn's training stimuli--an orange circle, a vertical line and a vertical line superimposed on an orange

circle. Each new element and the new compound were introduced twice within probe sessions. The new stimuli were alternated with the subjects' training stimuli, each presentation lasting one minute. Extinction was in effect throughout the new stimulus probes. From this point on, token exchanges occurred after 18 components for both subjects, with one token exchange in each session.

Phase 5--Establishment of novel color/line-tilt compounds as discriminative stimuli. The subjects' performance in the probe sessions indicated that discriminative responding acquired in Phase 3 was specific to the training schedule contingencies. Discriminative responding was not maintained with variations of the original stimulus dimensions. A second training procedure was initiated in which the new stimuli were presented during half of each session, and alternated in irregular order with the training stimuli. Under all four single elements, right lever responses were reinforced with tokens every minute, on the average, and left lever responses were followed by a two minute timeout on a VR 2 schedule. Under both compound stimuli, the left and right lever contingencies were reversed. To set up equal reinforcement rates on both levers, half of the sub-component stimuli presented were single elements, and half were compounds. Each presentation lasted one minute. The number of token exchanges per session and the average number of tokens per exchange for Sandy and Dawn in this phase are listed in Tables 1 and 2, respectively. Sandy required a total of seven sessions before performing without errors in three consecutive sessions. Dawn, on the other hand, failed to acquire the new discrimination after 28 sessions. Moreover, the discrimination

previously acquired under the training stimulus components was disrupted. The novel stimulus components were therefore withdrawn for Dawn, and as in Phase 3, only the original training stimuli were presented for 12 sessions. Following re-acquisition of the original discrimination, the training stimulus components were withdrawn, and the three novel stimulus components were reintroduced for seven sessions.

Sandy was trained on two additional color/line-tilt combinations with the probe-train procedure. A purple circle, a 45-degree right-tilt line and the corresponding compound were introduced under probe conditions, but discriminative responding did not occur. The training schedules were then introduced. The new stimuli were presented during half of each session as described above, and alternated in irregular order with the six discriminative stimuli for eight sessions. Following acquisition, a yellow circle, a 45-degree left-tilt line and the corresponding compound were introduced under probe conditions. Discriminative responding once again did not occur, and the training conditions described above were repeated. The new stimuli were presented during half of each session, and alternated in irregular order with the nine discriminative stimuli for seven sessions.

While Sandy's performance in the probes indicated that discriminative responding was specific to the stimuli associated with the training schedules, she nevertheless emitted progressively fewer errors in acquiring each successive discrimination. Differential reinforcement was therefore substituted for the extinction probes as an alternate test of stimulus control. Four novel color/line-tilt combinations were trained separately: a brown circle, a 68 degree

right-tilt line and the corresponding compound; a pink circle, a 68 degree left-tilt line and the corresponding compound; a blue circle, a 23 degree right-tilt line and the corresponding compound; and a red circle, a 23 degree left-tilt line and the corresponding compound. Each stimulus set was presented over two consecutive training sessions. Discrimination performance was obtained under each new condition as Sandy responded without errors across these eight successive training sessions.

Dawn's discrimination performance had been disrupted when the training schedules were instituted for two color/line-tilt combinations within the same sessions. However, she had required successively fewer sessions to reacquire the original discrimination and to master the second discrimination. Dawn was subsequently trained to respond under a third color/line-tilt combination--a yellow circle, a 45-degree left-tilt line and the corresponding compound--in isolation using the training schedules previously described.

RESULTS

Response rates were recorded after the completion of each multiple sub-component schedule, and the average rates of responding under the color, line-tilt and compound components were calculated for each session (see Appendix Tables 3 and 4 for a complete listing of average rates of responding under each component over successive sessions). The median response rates (i.e., responses per minute) for successive experimental conditions, numbered in their order of presentation, are shown in Figures 1, 2 and 3 for Sandy and Figure 4 for Dawn. Sandy's performance in the original training stimulus components are shown in the upper panels of Figure 1; the lower panels show her performance in the second set of color/line-tilt components. Sandy's performances are the third and fourth sets of color/line-tilt components are shown in Figure 2, upper and lower panels, respectively. Figure 3 shows Sandy's performance in the final four sets of color/line-tilt components. Dawn's performances in the original training stimulus components are shown in the upper panels of Figure 4. The lower panels show her performance in the second and third sets of color/line-tilt components. In each figure, the squares represent median rates on the color components; the triangles represent median rates on the line-tilt components; and the circles represent median rates on the compound components. Open symbols indicate responding on the lever correlated with reinforcement, while dark symbols represent responding on the lever

Figure 1. Sandy's median rates of responding in the first and second discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis. Open squares (□) represent rates on the color associated reinforcement lever; dark squares (■), rates on the color associated extinction/timeout lever. Open triangles (△) represent rates on the line-tilt associated reinforcement lever; dark triangles (▲), rates on the line-tilt associated extinction/timeout lever. Open circles (○) represent rates on the compound associated reinforcement lever; dark circles (●), rates on the compound associated extinction/timeout lever. In VR2:TO the number of responses actually followed by a timeout are plotted. The bars extending from symbols indicate the range for each measure. The reinforcement contingencies on each lever are indicated across experimental conditions.

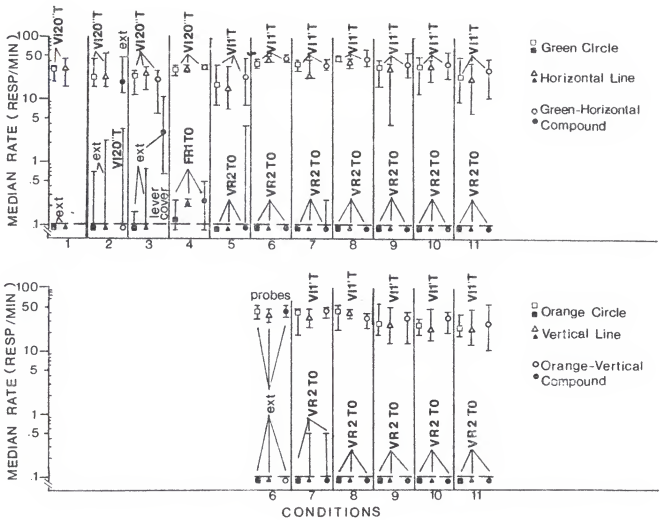

MEDIAN RATE (RESP/MIN)
100
50
10
5
1
.5
.1
ext
VI20"T
ext
VI20"T
ext
VI20"T
ext
lever cover
FR1TO
VI20"T
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
1
2
3
4
5
6
7
8
9
10
11
Green Circle
Horizontal Line
Green-Horizontal
Compound
MEDIAN RATE (RESP/MIN)
probes
ext
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
6
7
8
9
10
11
CONDITIONS
Orange Circle
Vertical Line
Orange-Vertical
Compound

Figure 2. Sandy's median rates of responding in the third and fourth discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis. Open squares (□) represent rates on the color associated reinforcement lever; dark squares (■), rates on the color associated extinction/timeout lever. Open triangles (△) represent rates on the line-tilt associated reinforcement lever; dark triangles (▲), rates on the line-tilt associated extinction/timeout lever. Open circles (o) represent rates on the compound associated reinforcement lever; dark circles (●), rates on the compound associated extinction/timeout lever. In VR2:TO the number of responses actually followed by a timeout are plotted. The bars extending from symbols indicate the range for each measure. The reinforcement contingencies on each lever are indicated across experimental conditions.

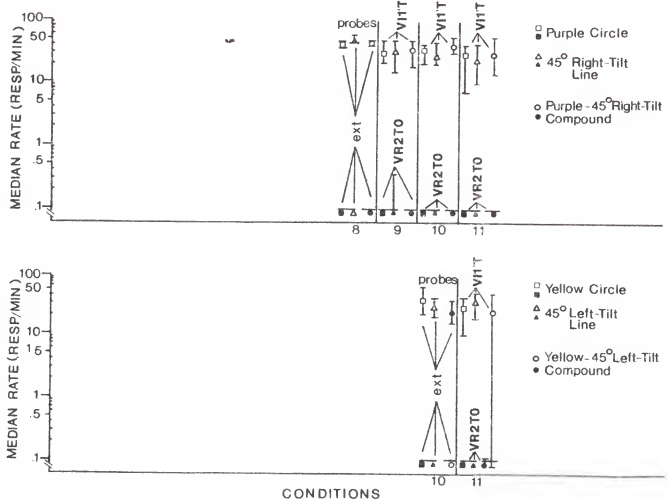
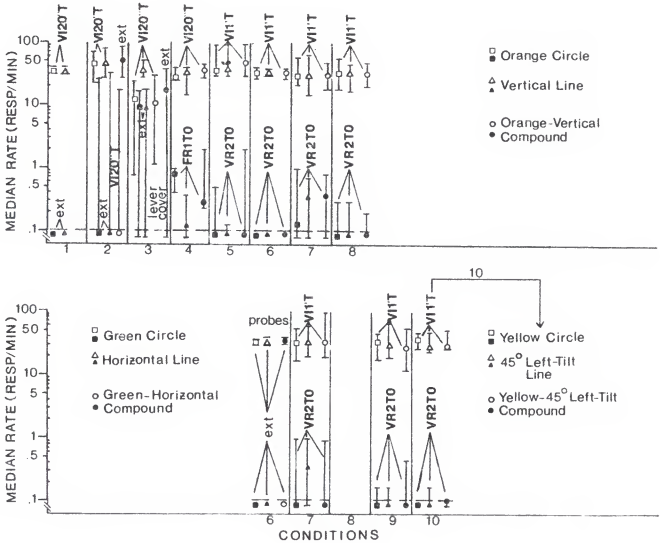

MEDIAN RATE (RESP/MIN)
100
50
10
5
1
.5
.1
probes
ext
VR2TO
VI1T
8
9
10
11
Purple Circle
45° Right-Tilt Line
Purple - 45° Right-Tilt Compound
Yellow Circle
45° Left-Tilt Line
Yellow - 45° Left-Tilt Compound
CONDITIONS

Figure 3. Sandy's median rates of responding in discriminations five through eight, plotted in their order of occurrence as numbered along the x-axis. Open squares (□) represent rates on the color associated reinforcement lever; dark squares (■), rates on the color associated extinction/timeout lever. Open triangles (△) represent rates on the line-tilt associated reinforcement lever; dark triangles (▲), rates on the line-tilt associated extinction/timeout lever. Open circles (o) represent rates on the compound associated reinforcement lever; dark circles (●), rates on the compound associated extinction/timeout lever. In VR2:TO the number of responses actually followed by a timeout are plotted. The bars extending from symbols indicate the range for each measure. The reinforcement contingencies on each lever are indicated across experimental conditions.

MEDIAN RATE (RESP/MIN)
100
50
10
1
5
.1
12
Brown Circle
68° Right-Tilt Line
Brown-68° Right-Tilt Compound
13
Pink Circle
68° Left-Tilt Line
Pink-68° Left-Tilt Compound
14
Blue Circle
23° Right-Tilt Line
Blue-23° Right-Tilt Compound
15
Red Circle
23° Left-Tilt Line
Red-23° Left-Tilt Compound
VR2TO
VIIT
CONDITIONS

Figure 4. Dawn's median rates of responding in the first, second and third discriminations, plotted across experimental conditions in their order of occurrence as numbered along the x-axis. Open squares (□) represent rates on the color associated reinforcement lever; dark squares (■), rates on the color associated extinction/timeout lever. Open triangles (△) represent rates on the line-tilt associated reinforcement lever; dark triangles (▲), rates on the line-tilt associated extinction/timeout lever. Open circles (o) represent rates on the compound associated reinforcement lever; dark circles (●), rates on the compound associated extinction/timeout lever. In VR2:TO the number of responses actually followed by a timeout are plotted. The bars extending from symbols indicate the range for each measure. The reinforcement contingencies on each lever are indicated across experimental conditions.


MEDIAN RATE (RESP/MIN)
100
50
10
5
1
.5
.1
VI20"T
ext
VI20"T
ext
VI20"T
ext
ext
lever cover
VI20"T
FR1TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
1
2
3
4
5
6
7
8
Orange Circle
Vertical Line
Orange-Vertical Compound
10
probes
ext
VI1"T
VR2TO
VI1"T
VR2TO
VI1"T
VR2TO
Green Circle
Horizontal Line
Green-Horizontal Compound
Yellow Circle
45° Left-Tilt Line
Yellow-45° Left-Tilt Compound
6
7
8
9
10
CONDITIONS

correlated with extinction/timeout. The specific multiple schedule contingencies associated with each lever are indicated across conditions. The bars extending from symbols represent the range recorded for each measure.

Responding in Multiple Schedule Components Signaled by Color, Line-Tilt and the Corresponding Color/Line-Tilt Compound

Equivalent rates of responding were maintained in the color and line-tilt components by both subjects in the two-component multiple schedule signaled by single elements. The first panel in Figures 1 and 4 shows the median response rate over the last nine sessions of the first condition for Sandy (i.e., 30 responses per minute), and for Dawn (i.e., 34 responses per minute), respectively. Both subjects stopped responding on the left (extinction) lever after nine sessions.

When the compound components were introduced, Sandy's median response rate in the single element components decreased slightly, but remained well within the range of the previous condition, as shown in the second panel of Figure 1. Throughout the 30 sessions in this condition, Sandy continued to respond on the right lever in the compound components at a median rate of 19 responses per minute, even though extinction was in effect. In the last session, she responded on the VI lever in five of the six compound components, averaging 3.5 responses per minute for the session. Sandy typically responded with her right hand only, and throughout this session she received three tokens for responding on the left lever in the compound components. The increased variability in error rates across single element components was also recorded during this session.

Dawn also continued to respond on the right lever throughout all compound components across 38 sessions in this condition. In fact, her median response rates on the right lever in the compound components were slightly higher than in the single element components, i.e., 51 responses per minute as compared to 42.5 and 45.5 responses per minute as shown in Figure 4, Panel 2. The only left lever responses emitted by Dawn in the compound components occurred in sessions 49 through 51. On these occasions, Dawn responded throughout most of the sessions with both hands simultaneously and only one token was delivered in session 49 for left lever responding. These three sessions accounted for the increased range in error rates across single element components, and in response rates on the reinforcement lever across compound components in this condition. On a number of occasions, a single left lever response was recorded in single element components. In all cases, these responses occurred simultaneously with right lever responses when Dawn positioned her left arm over the lever in a resting posture while responding with her right hand on the right lever.

Increasing the number of compound stimulus components did not generate reliable switch-overs for either subject. Even though Sandy made occasional responses on the left lever, right lever responses in the compound stimulus components did not deviate from previous levels at any time during these sessions.

As the third panel in Figure 4 shows, attempts to "force" switch-overs in the presence of the compound stimulus by covering the right lever were not effective with Dawn. While she responded on the left lever in the presence of the cover, Dawn immediately reverted back to the right lever when the cover was removed. The procedure was more

effective with Sandy, but as shown in the third panel of Figure 1, she continued to respond on the extinction lever throughout these sessions. An interesting lever pressing topography was observed at this time on the reinforcement lever in the compound components, as Sandy responded by pressing the left lever with her head.

When the extinction schedules were replaced by timeout (Panels 3 and 4), right lever responding in the compound components was eliminated after three sessions for Sandy, and after six sessions for Dawn. Thus, both subjects mastered the discrimination in relatively few sessions with the punishment contingency. At this time, the token reinforcement schedules were gradually leaned to VI 1 min., and the component requirement per exchange increased to FR 18 with one exchange at the completion of each session. During this transition, Sandy's response rates decreased to approximately 50% of the previous levels. Her rates recovered after the retraining period prior to session 69. Sandy's median response rates across the last seven sessions of this phase was 35 responses per minute in all three component stimuli on the corresponding VI levers. Dawn's rates increased sharply in the final week of this condition, and then returned to base levels. Her median rates over the last seven sessions were 51 and 61 responses per minute in the color and line-tilt components, respectively, and 61 responses per minute on the left lever in the compound stimulus components.

Responding in Stimulus Control Probes

Lower Panel 6 in Figures 1 and 4 shows each subject's performances in the stimulus control probes that followed acquisition of the discrimination; both subjects responded on the right lever in the

presence of all three novel stimuli. In the novel color and line-tilt components, 100% of the responses were made on the color and line-tilt associated reinforcement lever; but in the novel compound components, all responses were made on the compound associated timeout lever.

Discrimination Performance Under Novel Color/Line-Tilt Compounds

Sandy. Sandy mastered the new discrimination quickly as shown in lower Panel 7 of Figure 1. She received a total of four timeouts in the novel stimulus components: two in the vertical line and two in the orange-vertical compound components. She maintained nearly perfect accuracy in the training stimulus components as shown in upper Panel 7, receiving only one timeout in the green-horizontal compound component in the first session, and made no further errors after the fourth session.

In the second probe condition, shown in Figure 2, upper Panel 8, Sandy responded on the color associated reinforcement lever (i.e., right) in the purple components, and on the compound associated reinforcement lever (i.e., left) in the purple--45 degree right compound components. However, in the 45 degree right line-tilt components, 100% of her responses were on the line-tilt associated timeout (i.e., left) lever. She made no errors in the first two training sessions, and required only one timeout in the third session in the novel line-tilt component to master the discrimination. She maintained perfect accuracy in the remaining components throughout training, although her rates of responding became more variable across all components (see upper and lower Panel 9, Figure 1).

Lower Panels 10 and 11 of Figure 2 show Sandy's median rates of responding in the yellow, 45 degree left line-tilt and yellow-45 degree left compound components across probe and training conditions, respectively. As in the initial probes, Sandy responded on the right lever in all probe components. In the yellow and 45 degree left line-tilt components, 100% of the responses were made on the single element associated reinforcement lever (i.e., right), but in the corresponding compound components, all responses were made on the compound associated timeout lever. One timeout was delivered in the first training session in the compound component. Following this timeout, Sandy stopped responding altogether in the yellow-45 degree left compound components, but responded at previous levels throughout the remaining components. Twenty-two novel compound components were presented in the first training session. At the beginning of the second training session, 36 compound components were presented successively, but the subject did not respond as shown by the range bar in lower Panel 11. When the Experimenter manually guided her right hand towards the left lever, she physically resisted the prompt. She resumed left lever responding after the Experimenter modeled the response and produced a token. Her response rates in all components were subsequently maintained at previous levels, and she made no further errors after this session.

Sandy performed without errors in the final four novel stimulus combinations when each set was presented separately over two sessions. These results are shown in Figure 3, Panels 12 through 15.

Dawn. Unlike Sandy, Dawn did not acquire the new discrimination readily as shown in Figure 4, lower Panel 7. Dawn made errors

consistently throughout the first 28 training sessions in which the training schedules were in effect in all six multiple schedule components. In fact, the introduction of the novel component schedules disrupted Dawn's discriminative responding in the training stimulus components as shown in upper Panel 7 of Figure 4. On the 29th session of this condition the novel component schedules were eliminated, and only the original training stimulus components were presented (see upper and lower Panel 8). Dawn received two timeouts in the orange components, two in the vertical components, and five in the orange-vertical compound components before performing without errors. These conditions remained in effect over 12 sessions. The original stimuli were then withdrawn, and the novel stimuli reintroduced (see Panel 9). Dawn required a total of seven timeouts to master the new discrimination, five of which were delivered in the compound stimulus components. Both of these figures represent a substantial decrease from the number of responses which were followed by timeouts in the original discrimination (i.e., 47 vs. 8 and 7 timeouts). As shown in Panels 8 and 9, response rates on the reinforcement levers during both training conditions were maintained at levels equivalent to response rates in the previous phase. Dawn acquired the final discrimination rapidly. As Panel 10 shows, errors remained at or near zero levels throughout this training phase.

DISCUSSION

Standard discrimination training techniques which employ differential reinforcement to establish stimulus control of responding by simultaneous multiple cues are often ineffective with developmentally delayed children. Differential reinforcement alone is not sufficient to generate predictable stimulus control over responding by any or all elements of a compound stimulus with many of these subjects. Alternative teaching procedures which reliably reduce overselective responding in complex discrimination training tasks may eventually yield increased optimism in the learning prognosis of these children, especially in such important areas as language acquisition.

The purpose of the present study was to examine the applicability of one such alternative procedure in training two developmentally delayed overselective subjects to respond to simultaneous multiple cues. A multiple schedule was used in a two-lever procedure in order to establish independent stimulus-response classes with single and multiple cues. The results showed that when reinforcement and timeout were contingent on the occurrence of specific stimulus-response relations, both subjects learned to respond differentially in the presence of multiple vs. single elements signaling the contingencies in multiple schedule components.

Extinction and timeout were examined to assess the relative efficiency of each in decreasing errors and establishing discriminative

responding on the right and left levers in the presence of single and multiple elements, respectively. Following training under single elements, a compound stimulus composed of the combined single elements was introduced. Although extinction was in effect for responding on the right lever in the compound components, both subjects continued to respond on this lever for over 180 presentations of the compound at rates equivalent to those maintained on the same lever by the VI 20 sec. schedule in the single element components. Furthermore, with few exceptions, left lever responding remained at or near zero levels. Since the elements in the compound stimulus were in all respects equivalent to the single elements in the alternate components, it is not surprising given the subjects' reinforcement histories under single elements, that either or both elements of the compound continued to function as a discriminative stimulus for right lever responding. This is consistent with previous findings which showed that once a stimulus-response relation has been established, subjects may continue to respond for hundreds of trials under extinction in the presence of a single element if reinforcement is concurrently delivered in the presence of a compound containing the same element (Koegel & Schreibman, 1977). Moreover, in the present case, the reinforcement rates under the more frequently interspersed single elements (i.e., 2:1 single element to compound stimulus component ratio) were probably sufficient to maintain right lever responding in the presence of the compound stimulus signaling extinction. These results are congruent with those reported by Bijou (1961); in his early studies using multiple schedules with retarded children, responding in S-delta periods showed considerable resistance to extinction.

Manipulating the relative number and distribution of compound stimulus components in a single session did not significantly alter switch-over rates. Similar manipulations have been effective in establishing rapid acquisition of multiple schedule discrimination performance with developmentally delayed subjects (Orlando & Bijou, 1961), and it is possible that with further sessions these manipulations would have been effective with the present subjects as well. However, after one session, minimal gains in terms of switch-overs were obtained with Sandy, and none with Dawn. Moreover, both subjects' response rates on the extinction lever were maintained at previous levels. It therefore seemed advisable to examine other procedures that might prove more efficient in generating switch-overs, while retaining the same schedule contingencies.

Using a lever cover to "force" switch-overs was not effective with Dawn. As might be expected from studies using prompts (Koegel & Rincover, 1976; Schreibman, 1975), employing an added stimulus appeared to interfere with the acquisition of stimulus control by the designated discriminative stimulus, and attempts to transfer stimulus control from the lever cover to the training stimulus were ineffective. Although the procedure was more effective with Sandy, when the cover was removed, she continued to make alternate responses on the extinction lever across approximately 85 compound component presentations.

Sandy's errors decreased quickly when timeout was introduced, and she required a total of nine timeout periods to master the discrimination. Dawn, on the other hand, required 47 timeout periods before performing without errors. For both subjects, two-thirds of the timeout periods were delivered for errors in the compound stimulus

components, indicating that even after the introduction of the punishment contingency, the elements of the compound continued to exert considerable control over right lever responding. Cook and Rincover (1979) have pointed out that autistic and very young normal children (i.e., matched on "mental age") tend to use rigid response strategies in discrimination tasks involving multiple responses, and often fail to switch to alternative response strategies called for by the task. A tendency towards response perseveration was also evident with these subjects, particularly Dawn. However, with the timeout contingency, the number of stimulus cues and response classes sampled by both subjects reliably increased. The disparity between subjects in the amount of training required to reach mastery level was significant, though not unusual (e.g., Koegel & Schriebman, 1977). More importantly, the different speeds of acquisition should not overshadow the central issue addressed by the procedures and featured in the results--the course and pattern of acquisition was similar for both subjects.

Following mastery of the original discrimination, acquisition of subsequent discriminations involving variations of the original color and line-tilt dimensions progressed more rapidly. Sandy performed on the last four without errors in stimulus control test sessions using training schedule contingencies. Unlike Sandy, Dawn's performance was disrupted when two color/line-tilt combinations were presented within the same training sessions. It is interesting that the stimulus control exerted by the original training stimuli remained intact while the novel stimuli were initially introduced as probes. However, when the training schedules were in effect for all six stimuli, Dawn's errors in the presence of the original training stimuli increased by a factor of

1.7 over baseline. She received a total of 115 timeouts over 28 sessions across the six components. However, when each set of stimuli was presented separately, she reacquired the original discrimination after eight timeout periods, and the second discrimination after seven. While Sandy's performance strongly indicated that she had learned to respond on the basis of multiple vs. single cues, the data on Dawn were more equivocal. On the one hand, there was a substantial decrease in errors during reacquisition of the original discrimination, and acquisition of the second (17% and 13% of the original rate of responses followed by timeout, respectively). Moreover, errors remained at or near zero levels during acquisition of the third discrimination, throughout which, she received a maximum of one timeout per session. On the other hand, if she had learned to respond on the basis of multiple vs. single cues, the dramatic increase in errors observed when two sets of timuli were presented in the same sessions would not have been expected to occur. It is possible, however, that the disruption of stimulus control in the latter case was due to added variability in potential stimulus classes that resulted when two sets of stimuli were interspersed. With a single combination of stimuli, both the color and line-tilt dimensions were constant, and the only variant across each single element and the corresponding compound was the absence/presence of one cue. However, when a second set was introduced, the constant dimensions became variable. In this case, there were two variants across each compound and the single elements from the alternate set; i.e., presence/absence of one cue plus the varying value of the color/line-tilt dimensions. Thus, the number of controlling stimulus-response relations that may have been "inadvertently" acquired

by the subject in the course of training was increased. The disruption in Dawn's performance during this condition need not suggest the failure to acquire the discriminations on the basis of single vs. multiple cues, but may reflect instead the course of acquisition of new controlling stimulus-response relations generated by the increased variability in potential stimulus classes.

There were three questions of interest underlying this experiment. The first was whether discrimination performance to simultaneous multiple cues could be established using multiple schedules with otherwise overselective subjects. In a multiple schedule there are two or more component schedules of reinforcement, each associated with its distinctive discriminative stimulus. The results showed that when stimulus-response relations involving simultaneous multiple cues were directly controlled by arranging appropriate consequences for their occurrence in a multiple schedule, the experimentally designated stimulus-response relations were acquired by these subjects.

The second question concerned the identification of schedule contingencies that would most rapidly reduce errors, thus increasing the cost efficiency of the procedure. The results showed that errors were maintained at levels equivalent to reinforced rates when extinction was in effect, but were reduced quickly when two-minute timeout periods were substituted. It is likely that the cost efficiency of the procedure would be further increased by arranging a three-component multiple schedule at the onset of training, and eliminating the reinforcement histories under single cue training. Exposing subjects to the reinforcement and punishment contingencies associated with each stimulus-response relation concurrently may encourage more rapid

development of stimulus control by the compound stimulus and enhance the efficiency of the procedure. In the present experiment, this procedural variation may in fact have contributed to the increased speed of acquisition of each successive discrimination following the original.

The final question of interest was whether the subjects had acquired specific stimulus-response relations, or whether they had learned to discriminate on the basis of single vs. multiple cues given novel element combinations. With one subject the results clearly affirmed the latter. The results were not as clearly supportive with the second subject, although her increased proficiency in acquiring successive discriminations suggested some degree of generalization.

The most obvious implication suggested by the present findings is that the overselective responding of developmentally delayed children in discrimination tasks involving multiple cues can be modified, and the number of stimulus response relations acquired increased, by arranging appropriate reinforcement histories. An important, yet perhaps subtle point to note here is that, in order to deliver appropriate consequences following the occurrence of a stimulus-response relation, one must first be able to observe and measure the relation directly. When reinforcement is delivered for a single response only in the presence of a compound stimulus containing two cues, it is impossible to detect the specific stimulus-response relation(s) which is actually reinforced. In other words, it is impossible to track the development of stimulus control. In arranging appropriate consequences

for designated stimulus-response relations, the subjects in the present experiment were required to engage in two distinct response topographies such that, the occurrence of these relations could be observed and measured independently, and could thus be reinforced directly. The use of multiple response topographies seems advisable in training overselective subjects to respond to multiple vs. single cues, since it affords the opportunity to observe and measure the development of correct and incorrect response classes early in training, and to insure their incompatibility by arranging direct consequences for their occurrence.

Perhaps the most significant finding reported in this study was the greater effectiveness of timeout as compared to extinction in decelerating errors. In this procedure, responding on the extinction lever in the compound components was always ultimately followed by a stimulus change and reinforcement for responding in the single element components. It is possible that the increased intermittency of reinforcement on this lever served to increase resistance to extinction for responding on the lever in the compound components. In contrast, timeout produced a rapid and striking decrease in errors, and was clearly the more cost-efficient procedure. It appeared that with timeout, each stimulus acquired a dual function: a discriminative function for a specific response class(es), and a punishing function for the alternate response class(es). Under extinction, on the other hand, the designated response classes failed to acquire independent status. Moreover, after the subjects mastered the original discriminations, the rates of responses followed by timeout in each component across successive discriminations remained below .5 responses per

minute. The only exception was Dawn's performance when two stimulus sets were presented together within the same sessions. But, given the variability in potential stimulus classes occasioned by this manipulation, this exception might be attributed to the development of unobserved and unmeasured stimulus-response relations.

The subjects' improved accuracy with timeout is particularly interesting when one considers that in all probe conditions which preceded training, error rates in extinction occurred at levels equal to correct rates. The differential sensitivity to extinction and timeout observed in the subjects' responding was illustrated most dramatically by their performance on the final discriminations which were not preceded by probes. Sandy performed on the last four without errors, and in her third and final discrimination Dawn received a maximum of one timeout per session for errors. It is tempting to infer from these results that the efficiency of the training contingencies was increased when the exposure to extinction as a means of testing for stimulus control and the error rates therein obtained, were eliminated. However, the confidence of this inference is made questionable by the order in which experimental conditions were introduced, since the increased accuracy in performance in the later phases may also have been effected by cumulative training history. This question could be addressed directly by introducing training contingencies not preceded by probes earlier in the sequence, and conversely, by introducing probes prior to training in the later phases. It is possible that by eliminating extinction components and associated error rates one might increase the efficiency of timeout in decelerating errors during training. This would be doubly significant, and would imply that its

effectiveness in arranging for generalization could be concurrently maximized.

The influence of extinction probes on the subsequent course of acquisition of stimulus control seems particularly critical in light of recent findings using errorless discrimination training procedures. Fields (1978, 1979) reported that when probes in extinction were used in conjunction with fading procedures to measure acquisition of stimulus control by the new stimuli, the probes had a positive influence on the process of acquisition. Moreover, the earlier introduction of probes during fading resulted in earlier acquisition, whether the probes were presented under extinction (Fields, 1978, 1979) or reinforcement conditions (Fields, 1981).

While these findings may appear to conflict with the suggestions of the present results, they may in fact lend support to our interpretation. In the fading procedures, the same reinforcement contingencies were correlated with the compound stimulus and both single elements, such that the stimulus-response relations in all three instances were topographically and functionally equivalent. Throughout fading, therefore, correct responses during extinction probes were always followed by a training trial, that is, by reinforcement for responding in the presence of the novel element. Thus, differential reinforcement of correct stimulus-response relations probably contributed to the enhancing effects of the probes.

In contrast, the stimulus-response relation reinforced during compound stimulus training in the present case was topographically and functionally incompatible with the previously established single element-response relations. In this case, incorrect controlling

relations during extinction probes were differentially reinforced in a similar fashion. Whether extinction probes have a facilitative or retarding effect on acquisition of stimulus control may be determined by the subjects' reinforcement history with respect to errors, and the compatibility of this history with stimulus-response relations correlated with reinforcement during subsequent training.

APPENDIX

Table 3

Sandy's Mean Response Rate Per Session

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	32	5	18	18		
2	29	1	17	1		
3	28	0	28	0		
4	34	1	31	.5		
5	33	.25	32	0		
6	31	0	31	0		
7	12	.13	23	0		
8	29	0	32	.25		
9	28	.5	28	0		
10	30	0	30	0		
11	31	0	31	0		
12	29	0	29	0		
13	26	0	27	0		
14	19	0	29	0		
15	32	0	34	0		
16	30	0	41	0		
17	23	0	25	0		
18	30	0	36	0		
19	30	0	28	0	0	25
20	27	0	27	0	0	23

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
21	21	0	22	0	0	22
22	23	0	21	0	0	21
23	44	0	55	0	0	48
24	43	0	37	0	0	31
25	19	0	20	0	0	15
26	27	0	26	0	0	22
27	24	0	22	0	0	15
28	25	0	21	0	0	21
29	21	0	20	0	0	15
30	20	0	22	0	0	15
31	26	0	25	0	0	16
32	19	0	17	0	0	17
33	27	0	25	0	0	24
34	17	.17	21	0	0	19
35	19	0	18	0	0	13
36	28	0	21	0	0	23
37	21	0	19	0	0	20
38	25	0	24	0	0	18
39	23	0	23	0	.17	17
40	18	0	25	0	0	19
41	22	0	22	0	0	18
42	24	.17	20	0	0	17
43	17	0	16	0	0	14
44	19	0	21	0	0	21
45	21	0	18	0	0	18

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
46	18	0	19	0	0	21
47	20	0	22	0	0	20
48	22	0	22	0	3.5	20
49	26	0	19	0	2.4	18
50	29	0	25	0	3.5	19
51	22	0	28	0	6	6
52	28	0	26	0	20	1.3
53	25	0	30	0	23	12
54	13	0	15	0	19	.7
55	28	0	24	0	28	3.5
56	25	.25	33	.75	28	2
57	26	.25	27	.2	31	0
58	35	0	35	.25	35	.5
59	27	0	30	0	26	3.7
60	18	0	10	0	25	0
61	11	0	11	0	11	0
62	13	0	16	0	12	0
63	9	0	14	0	9	0
64	10	0	14	0	8	0
65	9	0	13	0	9	0
66	11	0	.8	0	11	0
67	12	0	11	0	12	0
68	8	0	.7	0	9	0
69	35	0	33	0	37	0
70	35	0	35	0	38	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
71	34	0	33	0	24	0
72	36	0	31	0	34	0
73	39	0	34	0	39	0
74	43	0	41	0	45	0
75	28	0	27	0	38	0
76	45	0	36	0	53	0
77	34	0	39	0	38	0
78	42	0	35	0	37	.25
79	33	0	36	0	48	0
80	29	0	36	0	30	0
81	37	0	35	0	45	0
82	33	0	41	0	52	0
83	41	0	40	0	47	0
84	39	0	36	0	48	0
85	46	0	41	0	61	0
86	48	0	33	0	34	0
87	44	0	40	0	45	0
88	38	0	33	0	25	0
89	17	0	4	0	23	0
90	47	0	37	0	41	0
91	45	0	30	0	62	0
92	35	0	35	0	31	0
93	43	0	34	0	55	0
94	29	0	14	0	36	0
95	32	0	16	0	37	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
96	46	0	41	0	41	0
97	18	0	35	0	45	0
98	14	0	20	0	23	0
99	49	0	41	0	32	0
100	29	0	15	0	23	0
101	18	0	25	0	30	0
102	47	0	21	0	38	0
103	41	0	14	0	10	0
104	18	0	37	0	37	0
105	32	0	30	0	31	0
106	11	0	16	0	36	0
107	9	0	6	0	20	0
108	45	0	15	0	43	0
109	19	0	18	0	14	0
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
76	55	0	50	0	0	55
77	31	0	31	0	0	35
78	45	0	36	0	44	.17
79	45	0	45	0	43	.5
80	18	0	24	.5	33	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
81	41	0	37	.5	40	0
82	42	0	28	0	49	0
83	41	0	26	0	40	0
84	30	0	43	0	49	0
85	51	0	49	0	49	0
86	42	0	21	0	23	0
87	35	0	29	0	35	0
88	18	0	35	0	32	0
89	18	0	15	0	14	0
90	38	0	49	0	40	0
91	37	0	39	0	36	0
92	22	0	29	0	35	0
93	57	0	16	0	17	0
94	26	0	25	0	32	0
95	30	0	23	0	39	0
96	33	0	26	0	40	0
97	31	0	35	0	34	0
98	17	0	27	0	28	0
99	22	0	26	0	19	0
100	24	0	35	0	38	0
101	21	0	34	0	47	0
102	27	0	58	0	52	0
103	39	0	22	0	26	0
104	35	0	43	0	27	0
105	17	0	35	0	30	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
106	21	0	15	0	11	0
107	31	0	29	0	18	0
108	38	0	35	0	46	0
109	34	0	14	0	25	0
	Purple Circle		45° R-T[b] Line		Purple-45° R-T[b] Compound[a]	
85	45	0	0	58	42	0
86	43	0	0	45	44	0
87	38	0	0	49	46	0
88	36	0	34	0	33	0
89	21	0	15	0	18	0
90	27	0	29	.35	45	0
91	41	0	37	0	42	0
92	30	0	33	0	31	0
93	38	0	48	0	47	0
94	29	0	30	0	35	0
95	25	0	29	0	29	0
96	20	0	44	0	39	0
97	40	0	33	0	40	0
98	29	0	30	0	30	0
99	37	0	31	0	52	0
100	31	0	11	0	25	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Purple Circle		45° R-T[b] Line		Purple-45° R-T[b] Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
101	26	0	14	0	38	0
102	28	0	26	0	33	0
103	15	0	30	0	43	0
104	42	0	20	0	20	0
105	27	0	28	0	17	0
106	15	0	12	0	15	0
107	14	0	30	0	40	0
108	60	0	41	0	51	0
109	7	0	30	0	15	0
	Yellow Circle		45° L-T[c] Line		Yellow-45° L-T[c] Compound[a]	
96	46	0	38	0	0	26
97	55	0	30	0	0	34
98	21	0	25	0	0	17
99	25	0	19	0	0	18
100	34	0	46	0	0	.05
101	39	0	28	0	3.4	0
102	25	0	38	0	37	0
103	15	0	20	0	26	0
104	25	0	18	0	30	0
105	23	0	33	0	26	0
106	26	0	21	0	18	0
107	40	0	42	0	14	0
108	33	0	33	0	17	0
109	26	0	17	0	45	0

Table 3--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Brown Circle		68° R-T[b] Line		Brown-68° R-T[b] Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
110	43	0	25	0	35	0
111	19	0	18	0	23	0
	Pink Circle		68° L-T[c] Line		Pink-68° L-T[c] Compound[a]	
112	21	0	16	0	18	0
113	24	0	18	0	20	0
	Blue Circle		23° R-T[b] Line		Blue-23° R-T[b] Compound[a]	
114	22	0	17	0	17	0
115	18	0	18	0	26	0
	Red Circle		23° L-T[c] Line		Red-23° L-T[c] Compound[a]	
116	23	0	21	0	27	0
117	15	0	14	0	10	0

[a]Under punishment conditions, the average rate of responses actually followed by timeout is indicated.

[b]R-T = right tilt.

[c]L-T = left tilt.

Table 4

Dawn's Mean Response Rate Per Session

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	13	4.5	42	0		
2	16	2	8	1		
3	38	0	30	0		
4	34	0	33	.25		
5	34	.8	33	.25		
6	24	1.5	25	0		
7	36	0	33	0		
8	24	0	32	.5		
9	17	.3	36	0		
10	31	0	32	0		
11	39	0	38	0		
12	34	0	37	0		
13	29	0	37	0		
14	40	0	30	0		
15	39	0	32	0		
16	35	0	39	0		
17	39	0	37	0		
18	39	0	.39	0		
19	37	0	40	0		
20	38	0	40	0		

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
21	39	.3	39	.43	0	48
22	51	0	49	0	0	57
23	44	0	43	0	0	51
24	50	0	49	0	0	44
25	45	.15	43	0	0	52
26	49	.3	45	.17	0	51
27	49	.15	53	.17	0	53
28	48	0	44	0	0	50
29	65	0	75	0	0	71
30	67	0	70	0	0	73
31	70	.3	64	0	0	67
32	45	0	47	0	0	51
33	47	0	50	0	0	54
34	41	0	57	.17	0	55
35	51	0	51	0	0	46
36	50	0	38	0	0	55
37	70	0	79	0	0	77
38	35	0	29	0	0	49
39	51	.15	55	0	0	62
40	35	0	50	0	0	51
41	33	0	37	0	0	42
42	35	0	34	0	0	41
43	29	0	39	0	0	57
44	34	0	27	0	0	29
45	27	0	29	0	0	37

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
46	61	0	52	0	0	58
47	63	0	43	0	0	57
48	62	0	49	0	0	57
49	55	0	51	0	0	59
50	52	27	43	33	17	45
51	33	13	30	18	13	32
52	29	6	33	8	9	28
53	35	0	31	0	0	25
54	31	0	39	0	0	32
55	33	.15	32	0	0	42
56	37	0	40	0	0	41
57	30	0	42	0	0	39
58	38	0	36	0	0	31
59	25	.5	33	.5	.18	35
60	23	0	28	0	11	18
61	12	9	33	9	26	13
62	27	.6	40	0	35	.3
63	40	1	35	.4	39	.26
64	29	.4	32	0	29	.23
65	39	.5	36	.15	35	.2
66	28	.4	29	0	29	.3
67	35	.25	33	0	35	0
68	33	.2	31	0	32	0
69	29	0	31	0	30	0
70	30	0	32	0	33	0

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
71	30	0	33	0	38	0
72	34	0	30	0	39	0
73	38	0	32	0	31	0
74	35	0	40	0	36	.5
75	34	0	37	0	33	.2
76	35	.17	38	0	38	0
77	36	0	37	0	36	0
78	38	0	50	0	40	0
79	30	0	38	0	35	0
80	33	0	35	0	39	0
81	36	0	36	0	37	0
82	52	0	51	0	50	0
83	41	0	42	0	41	0
84	61	0	61	0	51	0
85	37	0	37	0	45	0
86	62	0	62	0	69	0
87	91	0	92	0	93	0
88	78	0	65	0	63	0
89	44	0	37	0	53	0
90	40	0	35	0	47	0
91	26	0	31	0	27	0
92	33	0	40	0	42	.5
93	28	0	32	0	33	.17
94	37	0	33	.35	29	.6
95	59	.15	62	.7	49	.5

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
96	32	.25	37	.7	35	.5
97	29	0	30	.6	29	1
98	30	0	32	.35	39	.35
99	28	0	30	0	33	.8
100	34	0	38	0	33	.8
101	29	0	40	0	38	0
102	44	0	39	0	35	.7
103	35	0	29	.5	37	.45
104	28	.35	28	0	23	.38
105	31	.5	30	0	40	.25
106	30	.5	27	0	45	.25
107	27	.5	29	.5	28	.25
108	25	.5	29	.5	19	.25
109	24	0	19	0	20	0
110	25	0	19	.5	18	0
111	23	.5	15	.5	19	.6
112	24	0	17	.5	18	.75
113	25	0	22	.5	24	.2
114	22	0	27	.5	27	0
115	27	.5	28	0	25	.2
116	31	.5	45	0	31	.17
117	30	.65	35	.25	24	.75
118	30	.35	35	0	32	.25
119	30	1	34	0	31	.75
120	25	.3	34	0	37	.1

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Orange Circle		Vertical Line		Orange-Vertical Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
121	24	0	28	0	32	0
122	27	0	26	0	35	0
123	32	0	32	0	30	0
124	18	0	19	0	21	0
125	35	0	42	.35	42	.1
126	18	0	16	0	21	.1
127	38	0	37	0	33	.2
128	34	0	37	0	38	0
129	35	0	36	0	37	0
130	30	0	32	0	30	0
131	55	0	46	0	45	0
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
90	37	0	39	0	0	36
91	32	0	29	0	0	35
92	39	1	45	1	40	.6
93	31	0	39	1	32	.35
94	30	.35	29	.9	35	.75
95	56	0	60	.9	61	0
96	35	.35	58	.5	37	0
97	37	0	34	.5	32	0
98	42	0	34	0	37	.17
99	35	0	33	0	43	.9
100	33	0	35	0	34	.2

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
101	38	0	41	0	41	0
102	41	0	33	0	35	0
103	33	0	35	.5	35	0
104	29	0	24	0	33	0
105	38	0	25	.35	31	.23
106	32	0	28	.35	30	0
107	36	0	29	.35	35	0
108	25	0	30	0	19	0
109	17	.5	34	.35	19	0
110	22	0	38	0	22	0
111	16	.5	24	0	22	0
112	27	0	25	.7	20	0
113	28	0	22	.35	24	0
114	27	0	25	0	26	0
115	23	0	32	.35	25	0
116	24	0	40	0	37	0
117	58	1	39	0	39	0
118	31	.5	49	0	30	0
119	35	0	32	0	35	0
120	--	--	--	--	--	--
121	--	--	--	--	--	--
122	--	--	--	--	--	--
123	--	--	--	--	--	--
124	--	--	--	--	--	--
125	--	--	--	--	--	--

Table 4—Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Green Circle		Horizontal Line		Green-Horizontal Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
126	--	--	--	--	--	--
127	--	--	--	--	--	--
128	--	--	--	--	--	--
129	--	--	--	--	--	--
130	--	--	--	--	--	--
131	--	--	--	--	--	--
132	39	0	35	0	28	0
133	17	.15	19	0	13	.4
134	25	0	20	0	27	.1
135	27	0	30	0	24	0
136	45	0	65	0	53	0
137	40	0	39	0	41	0
138	35	0	29	0	32	0
	Yellow Circle		45° L-T[b] Line		Yellow 45° L-T[b] Compound[a]	
139	46	0	48	.16	51	0
140	37	0	24	.16	28	0
141	28	0	37	0	29	.1
142	39	0	27	0	31	.1
143	26	0	29	0	32	.1
144	34	0	34	0	46	0
145	35	0	36	0	36	0

Table 4--Continued

Session	Mean Response Rate (R's/min.) Per Component					
	Yellow Circle		45° L-T[b] Line		Yellow-45° L-T[b] Compound[a]	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
146	31	0	27	0	25	.1
147	28	0	31	0	28	0
148	30	0	21	.16	31	0
149	28	0	21	0	32	0
150	39	0	43	.16	32	0
151	35	0	42	0	40	0

[a]Under punishment conditions, the average rate of responses actually followed by timeout is indicated.

[b]L-T = left tilt.

REFERENCES

Bailey, S. L. Stimulus overselectivity in learning disabled children. Journal of Applied Behavior Analysis, 1981, 3, 239-248.

Bijou, S. W. Discrimination performance as a baseline for individual analysis of young children. Child Development, 1961, 32, 163-170.

Bijou, S. W., & Baer, D. M. Operant methods in child behavior and development. In W. K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts, 1966.

Bijou, S. W., & Orlando, R. Rapid development of multiple schedule performances with retarded children. Journal of the Experimental Analysis of Behavior, 1961, 4, 7-16.

Fields, L. Fading and errorless transfer in successive discriminations. Journal of the Experimental Analysis of Behavior, 1978, 30, 123-128.

Fields, L. Acquisition of stimulus control while introducing new stimuli in fading. Journal of the Experimental Analysis of Behavior, 1979, 32, 121-127.

Fields, L. Enhanced learning of new discriminations after stimulus fading. Bulletin of the Psychonomic Society, 1980, 15, 327-330.

Fields, L. Early and late introduction of probes and stimulus control acquisition in fading. Journal of the Experimental Analysis of Behavior, 1981, 36, 363-370.

Fields, L., Bruno, V., & Keller, K. The stages of acquisition in stimulus fading. Journal of the Experimental Analysis of Behavior, 1976, 26, 295-300.

Fischer, M. A., & Zeaman, D. An attention-retention theory of retardate discrimination learning. In N. R. Ellis (Ed.), International review of research in mental retardation. New York: Academic Press, 1973.

Hale, G. A., & Morgan, J. S. Developmental trends in children's component selection. Journal of Experimental Child Psychology, 1973, 15, 302-314.

Huguenin, N. H., & Touchette, P. E. Visual attention in retarded adults: Combining stimuli which control incompatible behavior. Journal of the Experimental Analysis of Behavior, 1980, 33, 77-86.

Johnson, D. F., & Cumming, W. Some determiners of attention. Journal of the Experimental Analysis of Behavior, 1968, 11, 157-166.

Johnston, J. M., & Pennypacker, H. S. Strategies and tactics of human behavioral research. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1980.

Koegel, R. L., & Rincover, A. Some detrimental effects of using extra stimuli to guide responding in autistic and normal children. Journal of Abnormal Child Psychology, 1976, 4, 59-71.

Koegel, R. L., Rincover, A., & Egel, A. L. Educating and understanding autistic children. San Diego, California: College-Hill Press, 1982.

Koegel, R. L., & Schreibman, L. Teaching autistic children to respond to simultaneous multiple cues. Journal of Experimental Child Psychology, 1977, 24, 299-311.

Koegel, R. L., & Wilhelm, H. Selective responding to the components of multiple visual cues by autistic children. Journal of Experimental Child Psychology, 1973, 15, 442-453.

Koorland, M. A., & Wolking, W. D. Effect of reinforcement on modality of stimulus control in learning disabled students. Learning Disabilities, 1982, 5, 264-273.

Lashley, K. S. An examination of the "continuity theory" as applied to discrimination learning. Journal of General Psychology, 1942, 18, 241-265.

LoLordo, V. M., & Furrow, D. R. Control by the auditory or the visual element of a compound discriminative stimulus: Effects of feedback. Journal of the Experimental Analysis of Behavior, 1976, 25, 251-256.

Lovaas, O. I., Koegel, R. L., & Schreibman, L. Stimulus overselectivity in autism: A review of research. Psychological Bulletin, 1979, 86, 1236-1254.

Lovaas, O. I., & Schreibman, L. Stimulus overselectivity of autistic children in a two stimulus situation. Behaviour Research and Therapy, 1971, 9, 305-310.

Lovaas, O. I., Schreibman, L., Koegel, R. L., & Rehm, R. Selective responding by autistic children to multiple sensory input. Journal of Abnormal Psychology, 1971, 77, 211-222.

Mackintosh, N. J. The effect of attention on the slope of generalization gradients. British Journal of Psychology, 1965, 56, 87-93.

Olson, D. R. Information-processing limitations of mentally retarded children. American Journal of Mental Deficiency, 1971, 75, 478-486.

Ray, B. A. The course of acquisition of a line-tilt discrimination by rhesus monkeys. Journal of the Experimental Analysis of Behavior, 1967, 10, 17-33.

Ray, B. A. Selective attention: The effects of combining stimuli which control incompatible behavior. Journal of the Experimental Analysis of Behavior, 1969, 12, 539-550.

Ray, B. A., & Sidman, M. Reinforcement schedules and stimulus control. In W. N. Schoenfeld (Ed.), The theory of reinforcement schedules. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970.

Reynolds, G. S. Attention in the pigeon. Journal of the Experimental Analysis of Behavior, 1961, 4, 203-208.

Reynolds, B. S., Newsom, C. D., & Lovaas, O. I. Auditory overselectivity in autistic children. Journal of Abnormal Child Psychology, 1974, 2, 253-263.

Rincover, A., & Koegel, R. L. Setting generality and stimulus control in autistic children. Journal of Applied Behavior Analysis, 1975, 8, 235-246.

Schover, L. R., & Newsom, C. D. Overselectivity, developmental level, and overtraining in autistic and normal children. Journal of Abnormal Child Psychology, 1976, 4, 289-298.

Schreibman, L. Effects of within-stimulus and extra-stimulus prompting on discrimination learning in autistic children. Journal of Applied Behavior Analysis, 1975, 8, 91-112.

Schreibman, L., Koegel, R. L., & Craig, M. S. Reducing stimulus overselectivity in autistic children. Journal of Abnormal Child Psychology, 1977, 5, 425-436.

Schreibman, L., & Lovaas, O. I. Overselective response to social stimuli by autistic children. Journal of Abnormal Child Psychology, 1973, 1, 152-168.

Segal, M., & Harrison, J. M. The control of responding by auditory stimuli: Interactions between different dimensions of the stimuli. Journal of the Experimental Analysis of Behavior, 1978, 30, 97-106.

Singh, N. N., & Beale, I. L. Attentional changes during discrimination learning by retarded children. Journal of the Experimental Analysis of Behavior, 1978, 29, 527-533.

Skinner, B. F. The behavior of organisms: An experimental analysis. New York: Appleton-Century-Crofts, 1938.

Terrace, H. S. Stimulus control. In W. K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts, 1966.

Varni, J. W., Lovaas, O. I., Koegel, R. L., & Everett, N. L. An analysis of observational learning in autistic and normal children. Journal of Abnormal Child Psychology, 1979, 7, 31-43.

Warren, J. M. Additivity of cues in a visual pattern discrimination by monkeys. Journal of Comparative Physiological Psychology, 1953, 46, 484-486.

Wilhelm, H., & Lovaas, O. I. Stimulus overselectivity: A common feature in autism and mental retardation. American Journal of Mental Deficiency, 1976, 81, 227-241.

Wilkie, D. M., & Mason, M. E. Attention in the pigeon: A reevaluation. Journal of the Experimental Analysis of Behavior, 1976, 26, 207-212.

Wyckoff, L. B., Jr. The role of observing responses in discrimination learning. Psychological Review, 1952, 59, 431-442.

Zeaman, D. One programmatic approach to retardation. In D. K. Routh (Ed.), The experimental psychology of mental retardation. Chicago: Aldine, 1973.

BIOGRAPHICAL SKETCH

Maria del Rosario Ruiz was born in La Habana, Cuba, on July 7, 1950, and is the daughter of Dr. Guillermo Vicente Ruiz and Dr. Maria Casas Ruiz. She left La Habana in August 1961 and entered the United States of America where she has resided over the past 21 years.

The author holds the Master of Education and the Master of Arts degrees from the University of Florida. During her tenure as a doctoral student at the same institution, she has worked as special education teacher for learning disabled children, behavioral trainer/consultant for Sunland, Gainesville, and outpatient drug abuse treatment counselor for a research facility sponsored by the College of Pharmacy at the University of Florida. During the past two years, she has been a doctoral-teaching fellow at Rollins College, where she is currently Assistant Professor of Psychology.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Henry S. Pennypacker, Jr.,
Chairperson
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Yvonne Brackbill
Graduate Research Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Mark K. Goldstein
Associate Professor of Psychology

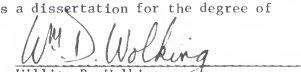
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James M. Johnston
Associate Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Edward F. Malagodi, Jr.
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



William D. Wolking
Professor of Special Education

This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December 1982

Dean for Graduate Studies
and Research